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A MEASUREMENT OF THE $b\bar{b}$ CROSS SECTION AT CDF

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ABSTRACT

We report on a measurement of the $b\bar{b}$ cross section at CDF from the 1992-1993 run of the Tevatron Collider. Dimuon events from inclusive $b \rightarrow \mu$ decays of $b\bar{b}$ pairs are used to obtain the cross section as a function of $P_T(b_1)$ and $P_T(b_2)$. The results are compared to the predictions of next-to-leading order QCD and are found to be consistent.

1. Introduction

In $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV, the strong coupling constant α_s becomes small for heavy quark production processes and perturbative QCD can provide reliable predictions. Studies of $b\bar{b}$ production provide an opportunity to check perturbative QCD at next-to-leading order.¹ In these proceedings we present a preliminary measurement of the $b\bar{b}$ cross section as a function of $P_T(b_1)$ and $P_T(b_2)$ using dimuon data with an integrated luminosity of $16.7 \pm 0.60 pb^{-1}$.

2. Data selection

Dimuon events are studied using inclusive $b \rightarrow \mu$ decays of $b\bar{b}$ pairs. At CDF, the muon identification is done by associating a track in the central tracking chamber (CTC) with a track in the central muon chamber (CMU).² The trigger requires at least 2 muons in the central region ($|\eta| < 0.6$). We also require P_T to be greater than 3 GeV/c for both muons.

The dimuon data come from $b\bar{b}$ production, $c\bar{c}$ production, Drell Yan, J/ψ , Υ , and *fakes*, where *fakes* are due to hadronic punchthroughs or decay muons from pions and kaons. The cascade decays of single b quarks and J/ψ dimuons are removed by requiring the dimuon invariant mass to be greater than 5 GeV/c². The $b\bar{b}$ production produces like-sign (LS) dimuons through $B^0\bar{B}^0$ mixing and the semileptonic decay from the daughter charm quark as well as opposite sign (OS) dimuons. *Fake* dimuon events with at least one *fake* contribute equally to LS and OS dimuons as there is no sign correlation between muons. The dimuons from all the other sources can be removed by requiring the sign of dimuons to be of like-sign as they only generate OS dimuons. The *fake* background fraction may be different in $\mu^-\mu^-$ and $\mu^+\mu^+$ sample and they must be treated separately. In this analysis we use $\mu^-\mu^-$ events.

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3. The Method

After the central muon chamber (CMU), there is a steel absorber followed by the central muon upgrade chamber (CMP).² The $b\bar{b}$ fraction in LS dimuon events is determined by measuring the CMP efficiency, the probability of muons having additional stubs in the CMP chamber. Most of the $b\bar{b}$ muons or decay muons from pions or kaons travel to the CMP while most of the hardronic punchthroughs are absorbed within the steel. With the CMP efficiency ϵ_μ for the $b\bar{b}$ muons and the CMP efficiency ϵ_f for *fakes*, we construct three equations for the three different types of dimuon events (CMU-CMU, CMU-CMP, and CMP-CMP).

$$N_{CMUCMU} = M + F_1 + F_2 \quad (1)$$

$$N_{CMUCMP} = 2\epsilon_\mu(1 - \epsilon_\mu)M + \{\epsilon_\mu(1 - \epsilon_f) + \epsilon_f(1 - \epsilon_\mu)\}F_1 + 2\epsilon_f(1 - \epsilon_f)F_2 \quad (2)$$

$$N_{CMPCMP} = \epsilon_\mu^2 M + \epsilon_\mu \epsilon_f F_1 + \epsilon_f^2 F_2 \quad (3)$$

where the N 's are the number of dimuon events of each type from the data and the subscript of N denotes the type of dimuon event. The number of the $b\bar{b}$ dimuon events is represented by M and the number of *fake* dimuon events by F . The subscript of F denotes the number of *fakes* in a event.

The CMP efficiency ϵ_μ is measured to be 0.94 ± 0.01 using J/ψ dimuons. The CMP efficiency ϵ_f is bounded from above analytically (0.53 ± 0.04) from those equations given the numbers available. The punchthrough probability³ of a K^- is almost equal to that of a π^- while the decay probability of a K^- to a CMU muon is greater than that of a π^- to a CMU muon. We set a lower limit on ϵ_f by determining the CMP efficiency of *fakes* from negative pions as the fraction of decay muons in π^- *fakes* is higher. This efficiency is measured to be 0.49 ± 0.04 from K_S^0 sample reconstructed with a negatively charged muon track and a positively charged track. From the equations and the CMP efficiencies, we calculate the number of $b\bar{b}$ dimuons, M , for different P_T thresholds for the second muon (3GeV/c, 4GeV/c, and 5GeV/c).

4. $b\bar{b}$ Cross Section

To obtain the $b\bar{b}$ cross section, the number of the $b\bar{b}$ dimuon events $N_{b\bar{b}}$ is divided by the dimuon reconstruction efficiency ϵ , the acceptance A , the branching ratio of the dual semimuonic decay of a $b\bar{b}$ pair,³ and the integrated luminosity L .

$$\sigma^{b\bar{b}}(P_T(b_1) > P_T^{min,1}, P_T(b_2) > P_T^{min,2}, |y_{1,2}^b| < 1) = \frac{N_{b\bar{b}}}{\epsilon \cdot A \cdot Br(b\bar{b} \rightarrow \mu_1 \mu_2 X) \cdot L} \quad (4)$$

The dimuon reconstruction efficiency is measured using J/ψ muons. The acceptance is determined using the $b\bar{b}$ generator based on next-to-leading order QCD calculations¹ and the CDF detector simulation. The b quark P_T^{min} is chosen such that 90% of the muons with $P_T > P_T^{thres}$ also have $P_T^b > P_T^{min}$. The corresponding P_T^{min} values are 6.5, 7.5, 8.75 GeV/c for $P_T^{thres} = 3.0, 4.0, 5.0$ GeV/c. We also use the value of $B^0 \bar{B}^0$ mixing parameter from CDF 1988-89 measurement⁴ for the acceptance calculations.

Table 1 shows the measurements of the $b\bar{b}$ cross section. The preliminary results are in good agreement with the CDF measurement using $e\mu$ data⁵ and consistent with next-to-leading order (NLO) QCD predictions as shown in Figure 1a.

Table 1. $b\bar{b}$ cross section

$P_T^{min,1}$	$P_T^{min,2}$	$\sigma^{b\bar{b}}$
6.5 GeV/c	6.5 GeV/c	$2.00 \pm 0.38(stat) \pm 0.37(sys) \mu b$
6.5 GeV/c	7.5 GeV/c	$1.71 \pm 0.42(stat) \pm 0.31(sys) \mu b$
6.5 GeV/c	8.75 GeV/c	$1.20 \pm 0.42(stat) \pm 0.24(sys) \mu b$

We also investigate the P_T correlations between the $b\bar{b}$ muons. Figure 1b shows the differential cross section of the observed dimuons as a function of $P_T(\mu_2)$ for $P_T(\mu_1) > 3$ GeV/c. We use the same method as in the $b\bar{b}$ cross section measurements to determine the number of $b\bar{b}$ dimuons for each P_T bin. The result is consistent with the prediction from NLO QCD and the detector simulation (CDFSIM).

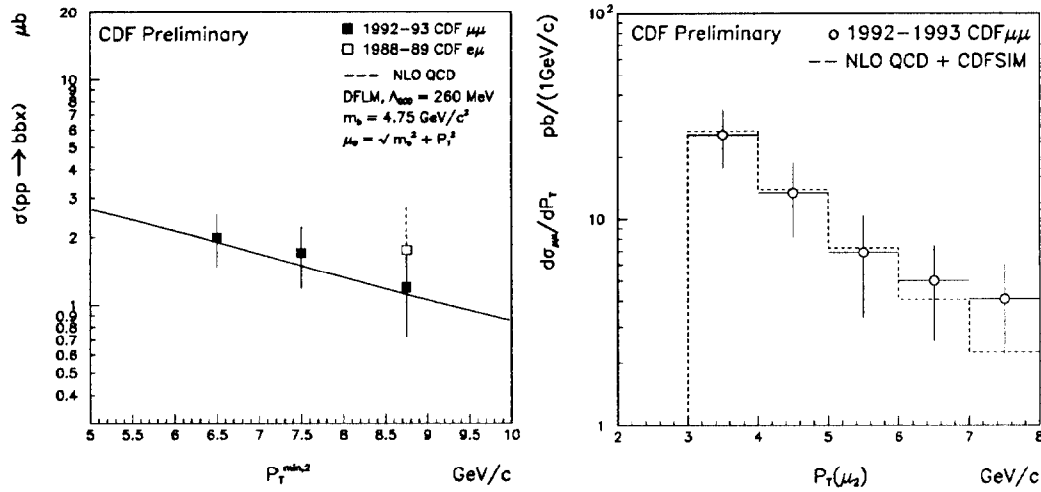


Fig. 1. a) $\sigma^{b\bar{b}}(P_T(b_1) > 6.5 \text{ GeV/c}, P_T(b_2) > P_T^{min,2}, |y_{1,2}^b| < 1)$ and b) $d\sigma_{\mu\mu}/dP_T(\mu_2)$ for $P_T(\mu_1) > 3 \text{ GeV/c}$.

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